AUTOMATIC FUEL VENT CLOSURE AND FUEL SHUTOFF APPARATUS HAVING MECHANICAL ACTUATION

RELATED APPLICATIONS

This application claims priority to U.S. Provisional Patent Application Serial No. 60/270,666 filed February 20, 2001.

FIELD OF THE INVENTION

The present invention relates to the field of internal combustion engines and, more particularly, to mechanically-actuated components in the fuel systems of internal combustion engines.

BACKGROUND OF THE INVENTION

Internal combustion engines are used in a variety of applications, such as lawn mowers, generators, pumps, snow blowers, and the like. Such engines usually have fuel tanks coupled thereto to supply fuel to the engine through a supply line. It is desirable to reduce emissions from devices powered by internal combustion engines. Even when the engine is not being used, the engine can release emissions of hydrocarbons or gasoline resulting from daily ambient temperature changes. Such emissions are known as "diurnal" emissions.

To help reduce emissions from the engine, it is known to provide internal combustion engines with fuel shutoff devices that block the flow of fuel to the engine upon engine ignition shutdown. Without such a shutoff device, fuel is wasted, and unburned fuel is released into the environment, thereby increasing exhaust emissions. Likewise, the presence of unburned fuel in the combustion chamber may cause dieseling. When the engine is not operating, pressure buildup

in the fuel tank caused by increased ambient temperatures can force fuel into the engine, where the fuel can be released into the atmosphere.

It is also desirable to reduce emissions from the fuel tank. Fuel tanks are typically vented to the atmosphere to prevent pressure buildup in the tank. While the engine is operating and drawing fuel from the fuel tank, the vent in the fuel tank prevents excessive negative pressure inside the tank. While the engine is not operating (i.e., in times of non-use and storage), the vent prevents excessive positive pressure that can be caused by fuel and fuel vapor expansion inside the tank due to increased ambient temperatures. Fuel vapors are released to the atmosphere, primarily when a slight positive pressure exists in the tank.

One common method of venting fuel tanks includes designing a permanent vent into the fuel tank cap. Typically, the fuel tank is vented via the threads of the screw-on fuel tank cap. Even when the cap is screwed tightly on the tank, the threaded engagement does not provide an air-tight seal. Therefore, the fuel tank is permanently vented to the atmosphere. Another method of venting fuel tanks includes the use of a vent conduit that extends away from the tank to vent vapors to a portion of the engine (i.e., the intake manifold) or to the atmosphere at a location remote from the tank.

SUMMARY OF THE INVENTION

The present invention provides a fuel vent closure device that is actuated automatically by the operation of a manually-operable engine control device such as a deadman or bail lever, a start/stop device such as a button, knob, or key, or a speed control device. In other words, the engine control device, which is already coupled to the ignition circuit to selectively start and stop the engine, is also

coupled to the vent closure device so that no additional action on behalf of the operator is required to actuate the vent closure device. In fact, the operator may not even know that the manual operation of the engine control device simultaneously actuates the vent closure device.

When the engine control device is remotely located from the engine and the fuel tank (as is the case with a deadman or bail lever on the handle of a walk behind lawn mower), the automatic actuation of the vent closure device occurs from a remote location. Linkage assemblies, which can include bowden cables, levers, cams, and other members, are used to remotely actuate the vent closure device.

In one aspect of the invention, the engine control device and the fuel vent closure device are also coupled to an automatic fuel shutoff device that blocks the flow of fuel to the internal combustion engine when the engine stops. Preferably, the single action of manually operating the engine control device causes actuation of each of the vent closure device, the fuel shutoff device, and the engine ignition system. Again, if the engine control device is remote from the engine and the fuel tank, linkages are used to remotely actuate the ignition switch, the vent closure device, and the fuel shutoff device. In a preferred embodiment, a single valve assembly acts as both the fuel vent closure device and the fuel shutoff device.

Other features and advantages of the invention will become apparent to those skilled in the art upon review of the following detailed description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view of an internal-combustion-engine-powered device having a deadman or bail lever coupled to a fuel vent closure and fuel shutoff device embodying the invention.

Fig. 2 is a schematic view of an internal-combustion-engine-powered device having an engine speed control device coupled to the fuel vent closure and fuel shutoff device embodying the invention.

Fig. 3 is a schematic view of another fuel vent closure and fuel shutoff device embodying the invention and coupled to an on/off device.

Fig. 4 is a schematic view of the fuel vent closure and fuel shutoff device of Fig. 3 coupled to an on/off/start device.

Figs. 5 and 6 show a fuel tank having a vent and a fuel supply port adapted to be connected to the fuel vent closure and fuel shutoff device.

Fig. 7 is a partial view of Fig. 6 showing an alternative vent configuration.

Figs. 8 and 9 show a mounting arrangement for the fuel vent closure and fuel shutoff device.

Figs. 10 and 11 show an alternative mounting arrangement for the fuel vent closure and fuel shutoff device.

Figs. 12 and 13 show a valve design that can be used for the fuel vent closure and fuel shutoff device.

Figs. 14 and 15 show another valve design that can be used for the fuel vent closure and fuel shutoff device.

Figs. 16 and 17 show yet another valve design that can be used for the fuel vent closure and fuel shutoff device.

Figs. 18-20 show yet another valve design that can be used for the fuel vent closure and fuel shutoff device.

Figs. 21-23 show yet another valve design that can be used for the fuel vent closure and fuel shutoff device.

Fig. 24 is a lawnmower having an internal combustion engine embodying the invention.

Fig. 25 is a portable generator having an internal combustion engine embodying the invention.

Fig. 26 is a portable pressure washer having an internal combustion engine embodying the invention.

Fig. 27 is an automatic backup power system having an internal combustion engine embodying the invention.

Fig. 28 is a multi-cylinder, V-twin internal combustion engine embodying the invention.

Fig. 29 is a single cylinder internal combustion engine embodying the invention.

Before one embodiment of the invention is explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced or being carried out in various ways. Also, it is understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including" and "comprising" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 schematically illustrates a device 10 having an internal combustion engine 14. In Fig. 1, the device 10 is illustrated as being a lawn mower 10a (see Fig. 24), but could alternatively be a snow blower (not shown), a portable generator 10b (see Fig. 25), a pump, such as the type commonly used in a portable pressure washer 10c (see Fig. 26), a stand-alone generator, such as the type commonly used for an automatic backup power system 10d (see Fig. 27), or the like. The engine 14 can be a multi-cylinder engine, such as a V-twin or opposed-cylinder engine 14a (see Fig. 28), or a single-cylinder engine 14b (see Fig. 29).

The lawnmower 10a includes an engine control device 18 coupled to the internal combustion engine 14. The engine control device 18 is manually operable to stop operation of the engine 14 by grounding an ignition switch 22. The engine control device 18 shown in Fig. 1 is known as a deadman lever or a bail lever and is mounted on the lawn mower handle 26, remote from the engine 14, as is commonly understood. A bowden cable or other suitable actuator 30 (shown schematically) connects the engine control device 18 to a linkage assembly 34 that actuates the ignition switch 22. Any suitable linkage assembly 34 can be used.

The engine control device 18 can also operate to stop the rotation of the blade (not shown). As seen in Fig. 1, an engine flywheel brake 38 is mounted on the linkage assembly 34. When the deadman lever is released (as shown in phantom in Fig. 1), the linkage assembly 34 is oriented such that the brake 38 engages a flywheel 42. Stopping the rotation of the flywheel 42 stops the rotation of the blade. Other blade braking mechanisms are also known and can be used instead of the engine flywheel brake 38.

The lawnmower 10a also includes a fuel tank 46 coupled to the engine 14 for providing fuel to the engine 14. More specifically, the fuel tank 46 supplies fuel to a carburetor 50 as is commonly understood. Of course, the engine 14 could also be a non-carbureted engine, in which case, fuel would be supplied to a fuel injection system. The fuel tank 46 is filled by removing a fill cap 54. Unlike prior art threaded fill caps, the fill cap 54 provides an air-tight seal when closing the fuel tank 46. The fill cap 54 can be configured in any suitable manner to close and seal the tank 46.

The fuel tank 46 also includes a vent 58 (shown schematically in Fig. 1) that can be selectively opened and closed as will be described below. Any suitable vent configuration that permits selective opening and closing can be used. Some examples of vent configurations are shown in Figs. 5-11. The vent 58 provides selective communication between the inside of the tank 46 and the atmosphere. When the vent 58 is open, the fuel tank 46 communicates with the atmosphere only via the vent 58. When the vent 58 is closed, the fuel tank 46 does not communicate with the atmosphere. Therefore, closing the vent 58 reduces diurnal emissions from the tank 46. The fuel tank 46 may be designed to accommodate pressure fluctuations caused by the expansion of fuel in the tank 46 when the vent 58 is closed.

The lawnmower 10a further includes a fuel vent closure device 62 that selectively opens and closes the vent 58. The fuel vent closure device 62 preferably includes a valve 66 (also shown schematically in Fig. 1) communicating between the vent 58 and a fuel vapor disbursal system, such as the air intake to the carburetor. The valve 66 can be of any suitable design. Several possible designs are shown in Figs. 12-23, which will be discussed below.

Opening the valve 66 opens the vent 58, thereby providing communication between the inside of the tank 46 and the atmosphere. Closing the valve 66 closes the vent 58, thereby preventing communication between the inside of the tank 46 and the atmosphere.

To reduce diurnal emissions from the fuel tank 46, the valve 66 should be closed when the engine 14 stops running, and should remain closed until the engine 14 is ready to be run or is running. To accomplish this, the vent closure device 62 is actuated automatically in response to the manual operation of the engine control device 18. In other words, when the operator releases the deadman lever to close the ignition ground switch 22 and stop the engine 14, the vent closure device 62 automatically closes the valve 66, thereby closing the vent 58. When the operator engages the deadman lever to open the ignition ground switch 22 for starting the engine, the vent closure device 62 automatically opens the valve 66, thereby opening the vent 58. By incorporating the operation of the vent closure device 62 with the manual operation of the engine control device 18, no additional action to open or close the vent 58 is required on behalf of the operator.

As seen in Fig. 1, the vent closure device 62 is remotely operated in response to movement of the linkage assembly 34. More specifically, the linkage assembly 34 includes an extension member 70 that moves in the direction of the arrows 74 in response to movement of the linkage assembly 34. When the operator actuates the engine control device 18, the extension member 70 moves with the linkage assembly 34 to selectively open and close the valve 66. An intermediate member 76 is coupled between the end of the extension member and a valve actuating member 78. Movement of the valve actuating member 78 opens and closes the valve 66.

It is appreciated that the vent closure device 62 need not be operated precisely in the manner shown in Fig. 1, but can be operated in other suitable manners using various other linkages or actuators known to those of ordinary skill in the art. Additionally, it is not necessary for the vent closure device 62 to automatically open the vent when the deadman lever is engaged for operation. Rather, the vent closure device 62 could operate automatically to close the vent 58 in response to release of the deadman lever, but could require additional action on behalf of the operator to manually open the vent 58 in order to run the engine 14.

The lawnmower 10a also preferably includes a fuel shutoff device 82 that selectively blocks the fuel supply to the carburetor 50. The fuel shutoff device 82 includes a valve 86 communicating between the fuel tank 46 and the carburetor 50. The valve 86 can be of any suitable design. Several possible designs are shown in Figs. 12-23, which will be discussed below. Opening the valve 86 provides fluid communication between the inside of the tank 46 and the carburetor 50. Closing the valve 86 blocks fluid communication between the inside of the tank 46 and the carburetor 50.

As shown in Fig. 1, the valve 86 for the fuel shutoff device 82 is actuated concurrently with actuation of the valve 66 for the vent closure device 62. The same linkage discussed above with respect to the vent closure device 62 also actuates the fuel shutoff device 82. Therefore, when the operator manually operates the engine control device 18 by releasing the deadman lever, the engine 14 stops running, the blade stops rotating, the fuel vent 58 is closed, and the fuel supply to the carburetor 50 is blocked. When the operator engages the deadman lever to permit running of the engine 14, the engine 14 can be started, the brake

38 is released, the vent 58 is opened, and the fuel supply to the carburetor 50 is unblocked.

As will be discussed in more detail below, it is possible to incorporate both valves 66 and 86 in a single valve assembly 90, thereby reducing the number of parts on the device. On the other hand, the fuel shutoff device 82 need not be actuated concurrently with, or via the same linkage as the vent closure device 62, and could be completely separate from the vent closure device 62.

Fig. 2 schematically illustrates a device 10c that is slightly different than the lawnmower 10a. The device 10c is illustrated as being a pump or a pressure washer (see Fig. 26), but could alternatively be a snow blower, a tiller, a string trimmer, or the like. The operation of the device 10c is substantially similar to the operation of the lawnmower 10a, with some exceptions which will be discussed below. Like parts have been given like reference numerals.

The device 10c includes an engine control device 18a in the form of a speed control device. The speed control device includes a speed control lever 94 on a linkage assembly 34a. The speed control lever 94 can be operated via a remote speed control lever (not shown) attached to a speed control cable 98, or directly via a friction speed control lever 102 extending from the linkage assembly 34a. As the device 10c does not include a rotating blade, such as is the case with a lawn mower, no brake is needed.

The fuel vent closure device 62 and the fuel shutoff device 82 operate in response to movement of the linkage assembly 34a in substantially the same manner as described above with respect to the lawnmower 10a. Therefore, when the operator manually operates the engine control device 18a by lowering the speed to a point where the ignition ground switch 22 is closed, the engine 14 stops

running, the fuel vent 58 is closed, and the fuel supply to the carburetor 50 is blocked. When the operator moves the speed control to a position where the ignition ground switch 22 is open and the engine 14 can run, the engine 14 can be started, the vent 58 is opened, and the fuel supply to the carburetor 50 is unblocked.

Fig. 3 schematically illustrates another manner of operating the fuel vent closure device 62 and the fuel shutoff device 82. Specifically, Fig. 3 illustrates a third engine control device 18b in the form of an on/off switch. The engine control device 18b can be used in conjunction with any devices, including, but not limited to, lawn tractors (not shown), generators 10b and 10d (see Figs. 25 and 27), pumps 10c (see Fig. 26), and the like.

The engine control device 18b can be of any suitable construction. As seen in Fig. 3, the engine control device 18b includes a rotatable shaft 106 that passes through a sleeve 110. A manually actuable knob portion 114 on the shaft 106 can be turned by the operator (either by hand or via a key) to cause the rotation of the shaft 106. An ignition grounding member 118 is operable to ground the ignition circuit, and thereby stop the running of an engine, when the knob portion 114 is turned to the OFF position.

The shaft 106 is also coupled to the valve 66 for the vent closure device 62 and to the valve 86 for the fuel shutoff device 82. Therefore, when the operator manually operates the engine control device 18b by turning the knob portion 114 to the OFF position, the engine stops running, the fuel vent is closed, and the fuel supply to the carburetor is blocked. When the operator turns the knob portion 114 to the ON position, the engine can be started, the vent is opened, and the fuel supply to the carburetor is unblocked.

Fig. 4 schematically illustrates a fourth engine control device 18c in the form of an on/off/start switch. The engine control device 18c operates in the same manner as the control device 18b, but includes a START position for the automatic starting of the engine. When the operator turns the knob portion 114 to the START position, the engine starts as is understood. Therefore, when the operator manually operates the engine control device 18c by turning the knob (either by hand or via a key) portion 114 to the OFF position, the engine stops running, the fuel vent is closed, and the fuel supply to the carburetor is blocked. When the operator turns the knob portion 114 to the START position, the engine is automatically started, the vent is opened, and the fuel supply to the carburetor is unblocked. After the engine is started, the knob portion 114 returns to the ON position where the engine keeps running, the vent remains open, and the fuel supply to the carburetor remains unblocked.

Figs. 5 and 6 show the fuel tank 46 and fuel tank vent 58 in greater detail. The vent 58 includes a connection port 120 adapted to be coupled to the valve 66 of the fuel vent closure device 62. Any suitable conduit (not shown) can be used to provide communication between the connection port 120 and the valve 66. As best seen in Fig. 6, the vent 58 can also include a baffle 122 that substantially prevents liquid fuel in the tank 46 from splashing out of the connection port 120. The baffle 122 can be any suitable, gasoline-resistant material and is preferably in the form of a disk that has a diameter slightly smaller than the diameter of the vent sidewalls. With this construction, liquid fuel cannot splash into the connection port 120, but air and fuel vapors can pass between the edge of the baffle 122 and the vent sidewalls for venting when the vent 58 is opened. The actual placement and design of the vent 58 in the tank 46 may be different than shown to get

optimum separation of liquid and vapor fuel. The vent 58 could also be located in the fuel cap 54.

Fig. 7 shows an alternative construction for preventing liquid fuel from splashing out of the connection port 120. The vent 58 includes a gasoline-resistant membrane 126 that is substantially pervious to air and fuel vapor, but is substantially impervious to liquid fuel. When the vent 58 is opened, air and fuel vapor can pass through the membrane 126, but liquid fuel cannot.

Fig. 6 also shows a fuel outlet port 130 located at the bottom of the tank 46. The fuel outlet port 130 is adapted to be connected to a conduit (not shown) that communicates with the valve 86 of the fuel shutoff device 82. It is important to note that the configuration of the fuel tank 46, the vent 58, and the fuel outlet port 130 is not limited to the configurations shown in the figures, but rather can be tailored to work in conjunction with a variety of devices having different types of fuel vent closure devices 62 and fuel shutoff devices 82.

For example, Figs. 8 and 9 illustrate an alternative embodiment wherein the connection port 120 and the fuel outlet port 130 extend substantially parallel to one another in the same plane. Instead of using conduit to connect the ports 120 and 130 to the respective valves 66 and 86, the valves 66 and 86 may be directly connected to the respective ports 120 and 130 outside of the fuel tank 46 as shown. The vent closure device 62 and the fuel shutoff device 82 may be part of a single valve assembly 90a, as shown, or alternatively may be two interconnected valve assemblies (not shown). The valves 66 and 86 are connected via a shaft 134 which rotates in response to rotation of the actuating member 78 to open and close the valves 66 and 86.

Figs. 10 and 11 illustrate an alternative embodiment wherein the valve assembly 90a is located at least partially inside the fuel tank 46. By positioning the valve assembly 90a inside the fuel tank 46, the number of parts can be reduced. Any suitable method of securing the valve assembly 90a inside the fuel tank 46 can be used. With this embodiment, the valve 66 is part of the vent 58 so that vapors escaping the tank 46 pass through the valve 66 prior to exiting the connection port 120. Likewise, air drawn into the tank 46 enters the connection port 120 prior to passing through the valve 66. The valve 86 is also inside the fuel tank 46 such that fuel passes through the valve 86 prior to exiting through the fuel outlet port 130.

There are numerous possible designs available for the valves 66 and 86, and for the valve assembly 90. For example, Figs. 12 and 13 illustrate one type of rotary valve assembly 90b that could be used. The valve assembly 90b includes an outer sleeve 138 having a vapor inlet 142, a vapor outlet 146, a fuel inlet 150, and a fuel outlet 154. It should be noted that the terms "vapor inlet" and "vapor outlet" are given with respect to the direction at which fuel vapor flows out of the tank 46, however, if air from the surroundings is flowing into the tank 46, the vapor outlet acts as an air inlet and the vapor inlet acts as an air outlet.

A rotatable shaft 158 is housed inside the outer sleeve 138. The shaft 158 includes two transverse holes extending therethrough. Hole 162 selectively provides fluid communication between the vapor inlet 142 and the vapor outlet 146, thereby acting as the valve 66, while hole 166 selectively provides fluid communication between the fuel inlet 150 and the fuel outlet 154, thereby acting as the valve 86. Seals 170 are positioned between the sleeve 138 and the shaft 158 to seal the gap between the sleeve 138 and the shaft 158.

As seen in Fig. 12, when the engine is not in operation, the shaft 158 is rotated such that the holes 162 and 166 are not aligned with the respective inlets 142, 150 and outlets 146, 154. In this position, no air or fuel vapor can pass through the valve 66 and no fuel can pass through the valve 86. The orientation shown in Fig. 12 is used when the engine is not operating. In Fig. 13, the shaft 158 is rotated such that the holes 162 and 166 provide fluid communication between the respective inlets 142, 150 and outlets 146, 154. The orientation shown in Fig. 13 is used during times of engine operation.

While the valve assembly 90b shown in Figs. 12 and 13 is illustrated with the inlets 142, 150, the outlets 146, 154, and the holes 162, 166 all being in the same plane, it should be understood that the components of the valve 66 and the valve 86 can be in different planes as well. Such would be the case when the valve assembly 90b were used with the embodiments shown in Figs. 8-11. Of course, with the valves 66 and 86 in different planes, the inlets 142, 150 and the outlets 146, 154 could be positioned anywhere along the circumferential periphery of the sleeve 138 to suit the configuration of the tank 46 and the ports 120, 130.

Figs. 14 and 15 illustrate another valve assembly 90c. The valve assembly 90c is a schematic of a sliding-spool directional-flow valve and includes an outer shell 174 having inlets 142, 150 and outlets 146, 154 that communicate with an inner cavity 178. The inner cavity 178 is open at one end for slidably receiving the end of a spool 182. The spool 182 includes four sealing disks 186 mounted in spaced relation from one another. Each of the disks 186 includes a seal ring 190 that can engage portions of the cavity wall as shown to selectively seal off portions of the cavity 178 between the disks 186.

The spool 182 is slidable into and out of the cavity 178 as seen in Figs. 14 and 15. A wiper seal 194 adjacent the open end of the cavity 178 seals the open end of the cavity 178 to substantially prevent vapors and fuel from leaking out between the spool 182 and the shell 174 during operation. Fig. 14 illustrates the closed position for the valves 66 and 86 and Fig. 15 illustrates the open position for the valves 66 and 86.

Figs. 16 and 17 illustrate a valve assembly 90d that is a schematic of a poppet valve. The operation of the valve assembly 90d is similar to the operation of the valve assembly 90c and like parts have been given like reference numerals. Instead of four disks 186, the spool 182 has only one disk 186. In addition to the single disk 186, poppets 198 formed on the spool 182 engage portions of the cavity wall to selectively seal off portions of the cavity 178 between the poppets 198 and the disk 186. A separate end cap 202 closes the end of the cavity 178 and includes the wiper seal 194. Fig. 16 illustrates the closed position for the valves 66 and 86 and Fig. 17 illustrates the open position for the valves 66 and 86.

Figs. 18-20 illustrate yet another valve assembly 90e. The valve assembly 90e is a schematic of an axial-sealing rotary valve and includes a housing 206 defining the inlets 142, 150 and the outlets 146, 154. A rotary member 210 is positioned within the housing 206 and rotates with respect to the housing 206 by actuation of a lever arm 214. The rotary member also includes a valve segment 218 having a vent aperture 222 and a fuel aperture 226 that selectively provide communication between the respective inlets 142, 150 and outlets 146, 154. Seals 230 are provided between the valve segment 218 and the housing 206.

When the valves 66 and 86 are in the open position, as shown in Fig. 18, the apertures 222 and 226 are aligned with the respective inlets 142, 150 and

outlets 146, 154 to provide fluid communication therebetween. When the valves 66 and 86 are in the closed position, as shown in Figs. 19 and 20, the apertures 222 and 226 are not aligned with the respective inlets 142, 150 and outlets 146, 154 and fluid communication is blocked.

Figs. 21-23 illustrate yet another valve assembly 90f. The valve assembly 90f is an eccentric wheel valve and includes a housing 234 having inlets 142, 150 and outlets 146, 154. A rotary member 238 is positioned inside the housing 234 and has an actuating portion 242 (see Fig. 23) extending out of the housing 234 through an end cap 246. The rotary member 238 includes upper and lower recesses 250 and 254, respectively.

A blocking member 258 is pinned in each of the recesses 250 and 254 and rolls along the inner wall of the housing 234 to selectively block and unblock the inlets 142, 150 as the rotary member 238 rotates. Of course the blocking members 250 could also be positioned to selectively block and unblock the outlets 146, 154. Seals 262 (see Fig. 23) isolate the recesses 250 and 254 from one another and from the environment outside of the housing 234. Fig. 21 illustrates the open position for the valves 66 and 86 and Figs. 22 and 23 illustrate the closed position for the valves 66 and 86.

Each of the valve assemblies 90 discussed above can be made from any suitable fuel-resistant materials and can be used interchangeably if the design of the device 10 so permits. It is understood that modifications to the tank 46 and the valve actuating linkages may be required depending on the type of valve assembly 90 used. Alternatively, changes to the valve assemblies 90 can be made to suit the tank and the actuating linkage configurations. It should also be noted that other valve assemblies 90 not shown or described can also be substituted. For example,

while the valves 66 and 86 are shown to typically open and close at the same time, alternative arrangements can be substituted where the vent valve 66 may be positioned or timed to open prior to the fuel valve 86, or vice-versa. Furthermore, the valve assemblies 90 need not incorporate both of the valves 66 and 86 as shown. Two separate valves 66 and 86 could be used and could incorporate any of the valve types discussed above.

Various features of the invention are set forth in the following claims.